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EXPERIMENTAL EVALUATION OF ATMOSPHERIC EFFECTS ON RADIOMETRIC MEASUREMENTS USING THE EREP OF SKYLAB. (EPN No. 439)

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EXPERIMENTAL EVALUATION OF ATMOSPHERIC EFFECTS ON RADIOMETRIC MEASUREMENTS USING THE EREP OF SKYLAB

1. LOGISTICAL SUMMARY

At the present time analysis awaits receipt of digital S192 data for our test site passes which has been on order, in addition to simulated S192 digital data from the Earth Resources Aircraft Program (ERAP) ground truth study in the Salton Sea test area. We continue to test and analyze the theoretical basis of our analysis program and gather data relevant to specifying all parameters as accurately as possible.

The following sections detail the work accomplished during the reporting period.

2. SURFACE CHARACTERISTIC DOCUMENTATION

EREP test site surface characteristics for this study have been documented in detail in the following manner:

2.1 Base Map Preparation - General Base

Maps were prepared to appropriate scale from S190B earth terrain photography (color IR for the Salton Sea area and aerial color for the Salt Lake - Bonneville area). These exhibits effectively demonstrate the relative surface homogeneity of the particular digital data seements which have been selected for further analysis.

2.2 Mineralogical - Topographical Survey - Overlays

Map overlays were prepared to scale which delineate the surface distribution of mineralogical species and relate regions of relatively uniform topography. A specific knowledge of these two factors is essential to successful implementation of the theoretical analysis.

Mineralogical information has been extracted from the appropriate USGS, state, and local maps which are available. In addition, when necessary, personal consultation with knowledgeable sources (e.g., University of Utah, Geology Department) was correlated with the published data available.

A complete geological analysis report was prepared for each site to accompany and explain the map overlays. These reports discuss surface mineralogy, uniformity, and morphology in addition to containing a key to the overlay.

A fundamental result of this documentation will be increased capacity to correctly identify the nature of the mineral species within the instrument field of view, and hence to choose an appropriate spectral reflectance curve from the library of data assembled to this date (See Section 3.2).

2.3 Orbital Overlays -

Base map overlays to appropriate scale were prepared tracing the S192 field of view for each ordered orbital pass and test site. Currently, these are passes 2 and 43 for the Salton Sea area and passes 5 and 39 for the Salt Lake - Bonneville region. Additionally, a similar overlay was prepared to cover the Earth Resources Aircraft Program ground truth flight for the Salton Sea region, Mission 238, Flight 17. The format for these overlays is identical, plotting GMT vs. position in the test site area from the appropriate accompanying field of view and navigation and guidance documentation. Using these tools, the specific digital data segment chosen for extended analysis will be portrayed against its mineralogical, topographical, and surface base maps.

2.4 Digital Radiances

Upon receipt, where feasible, digital radiances will be portrayed in similar format, possibly employing an intensity level contour map to delineate the effect of varying surface characteristics.

3. IMPLEMENTATION OF THEORETICAL ANALYSIS

3.1 The atmospheric transmittance program (Selby and McClatchey, 1972) has been implemented within the framework of a software package to calculate theoretical radiances and atmospheric effects for the SKYLAB S192 sensor. Appropriate values of the solar irradiance (Thekaekara, 1970), instrument filter functions, and sample surface spectral reflectance curves for a number of surface types have been coded for analysis.

3.2 Surface Spectral Reflectance Curves

A comprehensive library of reflectance curves has been assembled based on the work of Salisbury and Hunt at the Terrestrial Sciences Laboratory of the Air Force Cambridge Research Laboratories (Hunt, et al., 1970-1973). They have studied spectra of more than 200 mineral and 150 rock samples to determine the origin of spectral features and to assess the utility of the visible and near infrared region for remote sensing of rock type, and have isolated the drawbacks associated with attempting to categorize the surface reflectance spectrum of a mixed mineralogical species on the basis of pure sample measurements (J.W. Salisbury, personal communication). It is believed that their results and assessment of the problem will aid markedly in a realistic assignment of the most correct spectral reflectance curve based on the geological analysis (Section 2.2). Implementation of these considerations at the present will consist of isolating the surface species within the field of view with the most outstanding spectral reflectance features, selecting its spectral reflectance curve, masking it by an appropriate mixing factor, and averaging the continuous curve for each S192 channel segment by convoluting with the appropriate channel response function.

It is hoped that this approach will provide a realistic $r(\lambda)$.

3.3 Atmospheric Reflectance

A comprehensive study of the nature of the "atmospheric reflectance" term in the theoretical analysis (sometimes called path radiance) has been conducted for the purpose of isolating a suitable analytical model. Path radiance $I_A(\lambda, \Theta_o, R_\lambda)$, for a nadir viewing instrument is a function of channel λ, solar elevation angle Θ_o, and surface reflectance within the channel, R_λ. Based on the values published by Plass and Kattawar, 1968 for total reflected radiance vs. surface reflectance R_λ, it is concluded that the reflected radiance is well represented by a linear function of R_λ, (Griggs, 1973):

$$I_T \ (\lambda, R_\lambda) = I_T \ (\lambda, 0) + R_\lambda \ [I_T(\lambda, 1) - I_T(\lambda, 0)]$$

here I_T is the total reflected radiance within a channel characterized by wavelength λ and includes both the direct surface term I_S and the path radiance I_A. Since the direct surface path radiance $I_S \ (\lambda, R_\lambda)$ is a linear function of surface reflectance, the path radiance $I_A = I_T - I_S$ must also be a linear function of surface reflectance. Theoretical considerations based on the radiative transfer problem denoted as the "planetary problem" by Chandrasekhar (1960) lead to the same result in the first approximation.

The path radiance will be modeled in this manner using data from Plass and Kattawar and Fraser (1973). Based on his study, Fraser (personal communication) can provide computations of total radiance, path radiance, and flux of light scattered from models of the earth-atmosphere system. The earth's surface is assumed to reflect light according to Lambert's law with reflectivities of 0.0 (0.01) 0.08, 0.10 (o.10) 1.00. The atmosphere contains various models of particulates. Usually the solar zenith angle $\Theta_o = 0^o$. The polar angle increment is 2^o from 0^o to 88^o. The computations are made for λ = 0.4 μm, 0.75 μm, and 0.90 μm. Outside of atmospheric absorption regions, these data may be interpolated in wavelength within reason to cover relevant S192 channels. However, since path radiance is a function of surface reflectance, the surface reflectance spectrum assigned must be convoluted with channel information to determine path radiance. A problem remains in locating similar calculations in the near infrared.

4. FUTURE PLANS

Preliminary analysis of EREP data from SL-2 or aircraft data will be continued as data becomes available. Computer programs to process the digital tape data from the aircraft sensors from EREP will be prepared. Detailed analysis of the digital data will be initiated as they become available.

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